

**ADVANCED TRAINING IN  
OPEN SURGICAL SKILLS**

## OVERVIEW

This module is designed to teach advanced open knot-tying and suturing skills that include fine suture and needle handling within space-constrained and at-depth conditions. This curriculum consists of 6 exercises designed to teach advanced skills to individuals who have already mastered basic knot-tying and suturing. This curriculum is suitable for residents, fellows, and junior faculty in surgical fields. While knot-tying and suturing are applicable to other techniques, such as laparoscopic and robotic surgery, this curriculum focuses solely on open techniques.

### I. OBJECTIVES

By the end of this training curriculum participants should be able to demonstrate proficiency in:

1. a variety of advanced open needle handling skills.
2. a variety of advanced open suturing techniques, including the push-push-pull and pitch and catch techniques (described below) superficially and at depth, with fine (5-0 or 6-0) suture.
3. knot-tying with fine suture at depth with and without needles.

### II. ASSUMPTIONS

It is assumed that participants are proficient in basic suturing and knot-tying either through prior skills lab training and skill verification, clinical experience, or a combination thereof. This curriculum is generally not recommended for individuals at early stages of technical skill development.

### III. SUGGESTED READINGS

1. Greenberg AL, Karimzada MM, Brian R, Yap A, Luu HY, Ahmed S, Huang C-Y, Waits SA, Hirose R, Alseidi A, Rapp JH, O'Sullivan PS, Chern H, Syed SM. Assessment of Surgeon Performance of Advanced Open Surgical Skills Using a Microskills-based Novel Curriculum. *JAMA Netw Open.* **5**, e2229787 (2022).
2. Clafin J, Waits SA. Three dimensionally printed interactive training model for kidney transplantation. *J Surg Educ.* 2020;77(5):1013-1017.
3. Bingmer, K., Ofshteyn, A., Stein, S. L., Marks, J. M. & Steinhagen, E. Decline of open surgical experience for general surgery residents. *Surg Endosc* **34**, 967–972 (2020).
4. Bashankaev, B., Baido, S. & Wexner, S. D. Review of available methods of simulation training to facilitate surgical education. *Surg Endosc* **25**, 28–35 (2011).
5. Alkhoury, F., Martin, J. T., Contessa, J., Zuckerman, R. & Nadzam, G. The Impact of Laparoscopy on the Volume of Open Cases in General Surgery Training. *J Surg Educ* **67**, 316–319 (2010).
6. Ericsson KA. Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. *Acad Med.* 2004 Oct;79(10 Suppl):S70-81.

## IV. DESCRIPTION OF MODULE

The 6 tasks included in the curriculum are:

- 1) Suture tying without needle, at depth
- 2) Suture tying with needle, at depth
- 3) Continuous suturing, pitch and catch, superficial
- 4) Continuous suturing, push-push-pull, superficial
- 5) Continuous suturing, pitch and catch, at depth
- 6) Continuous suturing, push-push-pull, at depth

We suggest that surgical educators at the learner's home institution follow a curriculum consisting of 4 standardized components:

1) **Orientation:**

We suggest learners review video tutorials, explanations, and scoring for each task. These can be found on the website (<https://advancedopensurgicallskills.ucsf.edu/>).

2) **Pre-test (baseline assessment):**

During pre-testing, the learner will complete each task 1 time with no-warm up. An expert rater will time and score the task and these data will be documented for later comparison.

3) **Training (self-practice to improve performance):**

The orientation and pre-test may be followed by a self-training period, which can take place either in a skills lab (with trainers available) or in the learners home (with trainers provided to learners). The goal is to continue to improve performance through deliberate practice.

4) **Post-test (final assessment):**

After the self-training period, learners may schedule a post-test session with an expert rater, which again consists of performing each task 1 time. Learners' performance in the post-test may be compared to the pre-test. Additional practice, training, and re-testing may be recommended for ongoing improvement; retention testing may also be performed.

If completing baseline and final assessments in person is not feasible, you may choose to use an online platform such as [C1DO1](#) or [Practice](#), which would allow learners at your institution to upload videos of their performance so that surgical educators can provide asynchronous feedback and evaluation.

A specific time allotment for curriculum completion is desirable; we recommend that learners are allotted at least 10 hours of total practice time to complete the curriculum.

## V. SETUP – GENERAL INFORMATION

i. **Model** – 3D-printed iliac fossa model is used for all tasks

Develop and assemble at home institution with 3D printer specifications.

Materials needed:

- [Filament](#) (7 spools of 1.75mm of any color)
- [Helping hands](#)



ii. **Simulation Fabric** - [White spandex](#) cut to 10cm x 5cm with 1cm defect cut at middle. Double black dots marked by marker at either apex.



iii. **Instruments** – Fine pickups (e.g., Gerald or Debaquey) and fine needle holder (e.g., Castro or Ryder/BM27) are needed for all tasks.



Castro





Ryder/BM27

- iv. **Sutures** – Knot tying tasks use 75cm 6-0 prolene single or double armed suture; suturing tasks use 5-0 or 6-0 prolene with suture tail cut to 37.5cm.
- v. **Handedness** – This curriculum is built for left- and right-handed learners.

**VI. SETUP – SPECIFIC TASKS**

**Figure 1.**

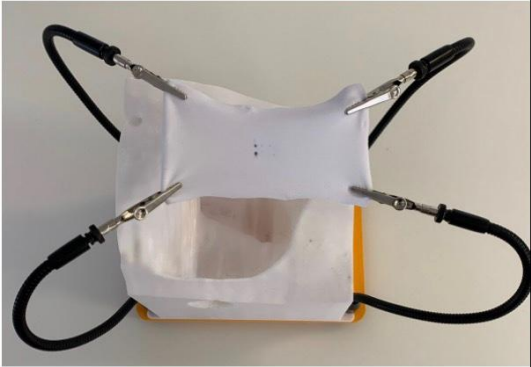

Suture tying without (Task 1) and with (Task 2) needle

<p>Model set-up</p>	<p>Simulation tissue positioned at base of iliac fossa model cavity</p>	
<p>Suture</p>	<p>6-0 single armed– C-1 Prolene (Task 1)*</p> <p>6-0 double armed– C-1 Prolene (Task 2)</p>	

\* Can use 6-0 single armed C-1 Prolene or cut needle off a 6-0 double armed C-1 Prolene



**Figure 2.**

Continuous suturing, superficial: pitch and catch (Task 3) and push-push-pull (Task 4)

Model set-up	Simulation tissue positioned above iliac fossa model cavity	
Suture	5-0 or 6-0	

**Figure 3.**

Continuous suturing at depth: pitch and catch (Task 5) and push-push-pull (Task 6)

<p>Model Setup</p>	<p>Slit fabric with dots positioned at base of iliac fossa model cavity</p>	
<p>Suture</p>	<p>5-0 or 6-0</p>	

## VII. TASK OVERVIEW

Each task will be timed and assigned a numeric score based on a set of specific micro-skills that is relevant for that task. These will serve as the basis for an overall performance score for the task.

- **Time:** Learners will be timed (in seconds) on their performance of each task from start to finish of the task. There will be a cutoff time associated with each task; the cutoff times were determined as 4 standard deviations away from the mean of benchmark scores.
- **Score:** Numeric scores will be determined based on the sum of individual scores for each micro-skill for a given task. Maximum possible score is 30 or 35, depending on the number of micro-skills associated with a task. Each micro-skill will receive a score from 1-5:

Score:	1	2	3	4	5
Description:	Unable to complete task	Completed task w/ major errors	Completed task w/ minor errors	Proficient, no errors, some awkward moves	Expert, no errors, smooth and efficient

- **Overall performance score:** Times (in seconds) and scores for each task may be converted to a single overall performance score (0-50) using a formula that incorporates expert performance and a relative time/score weighting. Expert participants were defined as those who had performed 50+ cases per year where advanced open skills were employed.
  - A template score calculator is provided; time/score weightings can be adjusted based on institution's preference.
  - A score of 50 (or higher) represents performance at the expert level; for every 10 points below 50, the score is 1 standard deviation away from expert performance.
  - Scoring formulas are derived from the following expert data:

Task	Score (Points)		Time (Seconds)		Example Scoring Formula <i>Using 25% Time/75% Score Weightings</i>
	Mean	SD	Mean	SD	
1	28.57	1.45	36.86	13.64	$((\text{Total score} - 28.57) / 1.45) * 0.75 - ((\text{Time} - 36.86) / 13.64) * 0.25) * 10 + 50$
2	33.86	1.17	41.14	11.61	$((\text{Total score} - 33.86) / 1.17) * 0.75 - ((\text{Time} - 41.14) / 11.61) * 0.25) * 10 + 50$
3	33.71	2.52	75.71	17.87	$((\text{Total score} - 33.71) / 2.52) * 0.75 - ((\text{Time} - 75.71) / 17.87) * 0.25) * 10 + 50$
4	27.57	2.56	113.07	23.33	$((\text{Total score} - 27.57) / 2.56) * 0.75 - ((\text{Time} - 113.07) / 23.33) * 0.25) * 10 + 50$
5	32.07	3.20	87.50	23.30	$((\text{Total score} - 32.07) / 3.20) * 0.75 - ((\text{Time} - 87.50) / 23.30) * 0.25) * 10 + 50$
6	28.50	2.41	126.79	34.24	$((\text{Total score} - 28.50) / 2.41) * 0.75 - ((\text{Time} - 126.79) / 34.24) * 0.25) * 10 + 50$



## VIII. DETAILED TASK DESCRIPTIONS

### Task 1: SUTURE TYING WITHOUT NEEDLE

**Summary:** This task requires using 1-handed technique to tie 10 knots with single armed suture.

**Equipment:** One fine needle holder, one fine forceps, one 75cm 6-0 Prolene single armed suture on a C1 needle. Task 1 model.

**Task set-up:** Throw a single suture through the two marked dots on the model.

**Task rules:** Hold ends of the suture in each hand (suture with needle in post hand). For each throw, use as many gathering maneuvers as needed and forefinger to lay down the knot securely.

**Timing:** The timing will start after the suture is in place and hand movement initiates (not crossed, one end in each hand).

**Cutoff time:** Maximum time for task completion is **90 seconds**. If the task is not completed within the allotted time, you will be asked to stop.

**Scoring:** A score is assigned for 6 micro-skills. Score assignments are based on the following:

Score:	1	2	3	4	5
<b>Description:</b>	Unable to complete task	Completed task w/ major errors	Completed task w/ minor errors	Proficient, no errors, some awkward moves	Expert, no errors, smooth and efficient

Micro-Skill	Score (1-5)
1) Throwing knot	
2) Suture gathering	
3) Suture sliding	
4) Atraumatic technique	
5) Maintenance of post	
6) Overall rating	
<b>Total (Sum of Scores for All Micro-Skills) [Max = 30]</b>	

**Scoring Formula:** see Task Overview or download template score calculator

**Expert Score:** 50

**Set up:**

1. See Figure 1.

**Task Completion:**

1. Load needle into fine needle holder.
2. Throw a single suture through the two marked dots on the model.
3. Set needle holder and forceps aside.
4. Hold the suture, uncrossed, in each hand with equal tails (suture with needle in post hand).  
(Time starts.)
5. Tie 2 slip knots then 8 square knots.
6. The task is completed when the last (10th) knot is secured. (Time stops.)

**Tips and Tricks:**

1. Make sure that the post hand is the hand with the needle.
2. Throw each knot above the level of the model cavity to maximize working space.
3. Three ways to avoid shortening on the 1st knot:
  - a. “See-saw” the 2 ends of the suture once the 1st knot is down to correct any length discrepancies prior to placing the 2nd knot; or
  - b. Keep your post elbow fixed against your chest wall to reduce lengthening the post hand; or
  - c. Overcompensate by starting with a tail end of the suture that is long anticipating some degree of shortening.
4. For slip knots, keep the post at 90 degrees with limited movement of the hand holding the post. For square knots, equal and opposite tension should be placed on the suture in opposite direction for each throw in order for each knot to lay down flat.

## TASK 2: SUTURE TYING WITH NEEDLE

**Summary:** This task requires using 1-handed technique to tie 10 knots with double armed suture.

**Equipment:** One fine needle holder, one fine forceps, one 75cm 6-0 Prolene double armed suture on a C1 needle. Task 2 model.

**Task set-up:** Throw a single suture through the two marked dots on the model.

**Task rules:** Hold ends of the suture in each hand. For each throw, use as many gathering maneuvers as needed and forefinger to lay down the knot securely.

**Timing:** The timing will start when suture is in place (not crossed, one end in each hand) and hand movement is initiated.

**Cutoff time:** Maximum time for task completion is 90 seconds. If the task is not completed within the allotted time, you will be asked to stop.

**Scoring:** A score is assigned for each micro-skill. Score assignments are based on the following:

Score:	1	2	3	4	5
<b>Description:</b>	Unable to complete task	Completed task w/ major errors	Completed task w/ minor errors	Proficient, no errors, some awkward moves	Expert, no errors, smooth and efficient

Micro-Skill	Score (1-5)
1) Throwing knot	
2) Gently allowing needle through without catching	
3) Suture gathering	
4) Suture sliding	
5) Atraumatic technique	
6) Maintenance of post	
7) Overall rating	
<b>Total (Sum of Scores for All Micro-Skill) [Max = 35]</b>	

**Scoring Formula:** see Task Overview or download template score calculator

**Expert Score:** 50

**Set up:**

1. See Figure 1.

**Task Completion:**

1. Load needle into fine needle holder.
2. Throw a single suture through the two marked dots on the model.
3. Set needle holder and forceps aside.
4. Hold the suture, uncrossed, in each hand with equal tails. (Time starts.)
5. Tie 2 slip knots then 8 square knots.
6. The task is completed when the last (10th) knot is secured. (Time stops.)

**Tips and Tricks:**

1. See Tips & Tricks for Task 1 (suture tying without needle)
2. Transiently release the tension on the post hand to allow the needle to have sufficient space to navigate through the suture without catching. If the needle does catch, gently moving both hands and relaxing tension on the post will help with recovery.

### TASK 3: CONTINUOUS SUTURING, SUPERFICIAL: PITCH & CATCH

**Summary:** This task requires 10 continuous superficial sutures using pitch and catch reloading technique.

**Equipment:** One fine needle holder, one fine forceps, one 5-0 or 6-0 Prolene suture on a C1 cut to 15cm. Task 3 model.

**Task rules:** Take single bites, entering and exiting at blue dots on either side of the slit. Use forceps to stabilize the tissue then grasp the needle. Use the forceps to atraumatically remove the needle from the tissue, then reload the needle into the needle holder on the field.

**Timing:** Time starts when the needle makes contact with the tissue for the 1st time.

**Cutoff time:** Maximum time for task completion is 150 seconds. If the task is not completed within the allotted time, you will be asked to stop.

**Scoring:** A score is assigned for each micro-skill. Score assignments are based on the following:

Score:	1	2	3	4	5
<b>Description:</b>	Unable to complete task	Completed task w/ major errors	Completed task w/ minor errors	Proficient, no errors, some awkward moves	Expert, no errors, smooth and efficient

Micro-Skill	Score (1-5)
1) Loading the needle with correct angle	
2) Releasing the needle in atraumatic fashion	
3) Grasping the needle in the forceps and atraumatic removal of the needle from the tissue	
4) Following the curve of the needle	
5) Coordinated transfer of the needle between the forceps and needle holder	
6) Reloading the needle in the correct angle for the next stitch	
7) Overall Rating	
<b>Total (Sum of Scores for All Micro-Skill) [Max = 35]</b>	

**Scoring Formula:** see Task Overview or download template score calculator

**Expert Score:** 50

**Set up:**

1. See Figure 2.

**Task Completion:**

1. Load needle into fine needle holder.
2. Time starts when the needle makes contact with the tissue for the 1st time.
3. Complete 10 continuous superficial sutures using pitch and catch reloading technique.
4. Time ends when the needle is removed from tissue for the last (10th) time.

**Tips and Tricks:**

1. Unlock needle holder before entering tissue; do not lock until needle is fully removed from tissue.
2. Use forceps to stabilize tissue at needle entry and exit.
3. Do not handle the needle tip with forceps (this will cause damage and blunting).
4. Follow the curve of the needle when removing it from tissue, do not torque.
5. Reload needle with hand pronated to be ready for the next bite.

### Task 4: CONTINUOUS SUTURING, SUPERFICIAL: PUSH-PUSH-PULL

**Summary:** This task requires 10 continuous superficial sutures using push-push-pull reloading technique.

**Equipment:** One fine needle holder, one fine forceps, one 5-0 or 6-0 Prolene suture on a C1 cut to 15cm. Task 4 model.

**Task rules:** Take single bites, entering and exiting at blue dots on either side of the slit. Use forceps to stabilize the tissue. Reload needle while still in tissue then atraumatically remove. Lock the needle driver after the needle is completely removed from tissue, then rotate the needle holder in preparation for the next bite.

**Timing:** Time starts when the needle makes contact with the tissue for the 1st time.

**Cutoff time:** Maximum time for task completion is 200 seconds. If the task is not completed within the allotted, you will be asked to stop.

**Scoring:** A score is assigned for each micro-skill. Score assignments are based on the following:

Score:	1	2	3	4	5
<b>Description:</b>	Unable to complete task	Completed task w/ major errors	Completed task w/ minor errors	Proficient, no errors, some awkward moves	Expert, no errors, smooth and efficient

Micro-Skill	Score (1-5)
1) Loading the needle with correct angle	
2) Releasing the needle in atraumatic fashion	
3) Pushing the needle through the tissue in atraumatic fashion	
4) Reloading the needle in the correct orientation for the next stitch	
5) Following the curve of the needle	
6) Overall Rating	
<b>Total (Sum of Scores for All Micro-Skills) [Max = 30]</b>	

**Scoring Formula:** see Task Overview or download template score calculator

**Expert Score:** 50

**Set up:**

1. See Figure 2.

**Task Completion:**

1. Load needle into fine needle holder.
2. Time starts when the needle makes contact with the tissue for the 1st time.
3. Complete 10 continuous superficial sutures using push-push-pull reloading technique.
4. Time ends when the needle is removed from tissue for the last (10th) time.

**Tips and Tricks:**

1. Unlock needle holder before entering tissue; do not lock until needle is fully removed from tissue.
2. Use forceps to stabilize tissue at needle entry and exit.
3. Do not handle the needle tip with forceps (this will cause damage and blunting).
4. Follow the curve of the needle when removing it from tissue, do not torque.
5. For push-push-pull, introduce the needle into the tissue far enough to expose at least 50% of the needle, so that the final loading of the needle with the needle holder will be in the appropriate segment of the needle.



## TASK 5: CONTINUOUS SUTURING AT DEPTH: PITCH & CATCH

**Summary:** This task requires 10 continuous sutures at depth using pitch and catch reloading technique.

**Equipment:** One fine needle holder, one fine forceps, one 5-0 or 6-0 Prolene suture on a C1 cut to 15cm. Task 5 model.

**Task rules:** Take single bites, entering and exiting at blue dots on either side of the slit. Use forceps to stabilize the tissue then grasp the needle. Needle should be re-loaded on the field at the point of exit from the tissue in the iliac fossa model cavity.

**Timing:** Time starts when the needle makes contact with the tissue for the 1st time.

**Cutoff time:** Maximum time for task completion is 180 seconds. If the task is not completed within the allotted time, you will be asked to stop.

**Scoring:** A score is assigned for each micro-skill. Score assignments are based on the following:

Score:	1	2	3	4	5
<b>Description:</b>	Unable to complete task	Completed task w/ major errors	Completed task w/ minor errors	Proficient, no errors, some awkward moves	Expert, no errors, smooth and efficient

Micro-Skill	Score (1-5)
1) Loading the needle with correct angle	
2) Releasing the needle in atraumatic fashion	
3) Grasping the needle in the forceps and atraumatic removal of the needle from the tissue	
4) Following the curve of the needle	
5) Coordinated transfer between of the needle between the forceps and needle holder	
6) Reloading the needle in the correct angle for the next stitch	
7) Overall Rating	
<b>Total (Sum of Scores for All Micro-Skills) [Max = 35]</b>	

**Scoring Formula:** see Task Overview or download template score calculator

**Expert Score:** 50

**Set up:**

1. See Figure 3.

**Task Completion:**

1. Load needle into fine needle holder.
2. Time starts when the needle makes contact with the tissue for the 1st time.
3. Complete 10 continuous sutures at depth using pitch and catch reloading technique.
4. Time ends when the needle is removed from tissue for the last (10th) time.

**Tips and Tricks:**

1. Load your needle at a 100-150 degree angle.
2. Unlock needle holder before entering tissue; do not lock until needle is fully removed from tissue.
3. Use forceps to stabilize tissue at needle entry and exit.
4. Do not handle the needle tip with forceps (this will cause damage and blunting).
5. Follow the curve of the needle when removing it from tissue, do not torque.
6. Reload needle with hand pronated to be ready for the next bite.

## TASK 6: CONTINUOUS SUTURING AT DEPTH: PUSH-PUSH-PULL

**Summary:** This task requires 10 continuous sutures at depth using push-push-pull reloading technique.

**Equipment:** One fine needle holder, one fine forceps, one 5-0 or 6-0 Prolene suture on a C1 cut to 15cm. Task 6 model.

**Task rules:** Take single bites, entering and exiting at blue dots on either side of the slit. Use forceps to stabilize the tissue. Reload needle while still in tissue then atraumatically remove. Lock the needle driver after the needle is completely removed from tissue, then rotate the needle holder in preparation for the next bite.

**Timing:** Time starts when the needle makes contact with the tissue for the 1st time.

**Cutoff time:** Maximum time for task completion is 260 seconds. If the task is not completed within the allotted time, you will be asked to stop.

**Scoring:** A score is assigned for each micro-skill. Score assignments are based on the following:

Score:	1	2	3	4	5
<b>Description:</b>	Unable to complete task	Completed task w/ major errors	Completed task w/ minor errors	Proficient, no errors, some awkward moves	Expert, no errors, smooth and efficient

Micro-Skill	Score (1-5)
1) Loading the needle with correct angle	
2) Releasing the needle in atraumatic fashion	
3) Pushing the needle through the tissue in atraumatic fashion	
4) Reloading the needle in the correct orientation for the next stitch	
5) Following the curve of the needle	
6) Overall Rating	
<b>Total (Sum of Scores for All Micro-Skill) [Max = 30]</b>	

**Scoring Formula:** see Task Overview or download template score calculator

**Expert Score:** 50

**Set up:**

1. See Figure 3.

**Task Completion:**

1. Load needle into fine needle holder.
2. Time starts when the needle makes contact with the tissue for the 1st time.
3. Complete 10 continuous sutures at depth using push-push-pull reloading technique.
4. Time ends when the needle is removed from tissue for the last (10th) time.

**Tips and Tricks:**

1. Load your needle at a 100-150 degree angle.
2. Unlock needle holder before entering tissue; do not lock until needle is fully removed from tissue.
3. Use forceps to stabilize tissue at needle entry and exit.
4. Do not handle the needle tip with forceps (this will cause damage and blunting).
5. Follow the curve of the needle when removing it from tissue, do not torque.
6. For push-push-pull, introduce the needle into the tissue far enough to expose at least 50% of the needle, so that the final loading of the needle with the needle holder will be in the appropriate segment of the needle.

## **IX. RECOMMENDATIONS FOR PRACTICE**

### **a. Distributed Practice**

For optimal benefits, self-training and practice should be conducted in a distributed fashion, in which individual training sessions are limited to relatively small durations in length. We recommend a maximum duration of up to 2 hours per training session (not to exceed 2 sessions in 1 day) so as to ensure that mental and physical fatigue is minimized and maximum retention and acquisition of technical skills is achieved. Practice sessions may be conducted (based on the learner's discretion and time availability) multiple times per week.

### **b. Structured Practice**

We recommend administering the curriculum in a structured fashion with specific timelines designated for all components (orientation, pre-test, training, and post-test).

### **c. Track Performance**

We recommend recording scores from each assessment so that progress can be tracked. By monitoring learner performance, mentoring and feedback can be provided to individuals who are having difficulty acquiring skills.

### **d. Deliberate Practice**

As defined by Dr. K Anders Ericsson, deliberate practice consists of three components: (1) improving particular aspects of performance for a discrete task with (2) immediate and detailed feedback and the (3) opportunity for repeated practice. Thus, we recommend for the learner to set aside time to practice in dedicated intervals with observation for directed feedback. Furthermore, our scoring formula is relative to expert performance and we hope the learner will continue to improve performance with deliberate practice.

## **X. LAB MANAGER MANUAL: SUPPLIES & STATION SETUP**

### **a. Suture tying without needle**

- 3D-printed iliac fossa model
- Slit fabric with 2 dots
- 75cm 6-0 single armed–C-1 Prolene [or 6-0 double armed–C-1 Prolene]
- One fine needle holder (e.g., Castro, BM27, Ryder)
- One fine forceps (e.g., Gerald, Debaquey)
- Suture pad

### **b. Suture tying with needle**

- 3D-printed iliac fossa model
- Slit fabric with 2 dots
- 75cm 6-0 double armed–C-1 Prolene
- One fine needle holder (e.g., Castro, BM27, Ryder)
- One fine forceps (e.g., Gerald, Debaquey)
- Suture pad

### **c. Continuous suturing, pitch and catch, superficial**

- 3D-printed iliac fossa model
- Slit fabric with 2 dots
- One fine needle holder (e.g., Castro, BM27, Ryder)
- One fine forceps (e.g., Gerald, Debaquey)
- One 5-0 or 6-0 Prolene suture on a C1 cut to 15cm
- Suture pad

### **d. Continuous suturing, push-push-pull, superficial**

- 3D-printed iliac fossa model
- Slit fabric with 2 dots
- One fine needle holder (e.g., Castro, BM27, Ryder)
- One fine forceps (e.g., Gerald, Debaquey)
- One 5-0 or 6-0 Prolene suture on a C1 cut to 15cm
- Suture pad

### **e. Continuous suturing, pitch and catch, at depth**

- 3D-printed iliac fossa model
- Slit fabric with 2 dots
- One fine needle holder (e.g., Castro, BM27, Ryder)
- One fine forceps (e.g., Gerald, Debaquey)
- One 5-0 or 6-0 Prolene suture on a C1 cut to 15cm
- Suture pad

### **f. Continuous suturing, push-push-pull, at depth**

- 3D-printed iliac fossa model
- Slit fabric with 2 dots
- One fine needle holder (e.g., Castro, BM27, Ryder)
- One fine forceps (e.g., Gerald, Debaquey)
- One 5-0 or 6-0 Prolene suture on a C1 cut to 15cm
- Suture pad

## **XI. TIME LENGTH FOR MODULES**

### **a. Orientation**

The video tutorial and website review consists of dedicated content for each task with some information and video demonstrations for correct performance as well as separate videos for common pitfalls and tips to avoid them. Reviewing this information takes approximately 1 hour.

### **b. Pre-Test**

Completing a monitored pre-test takes approximately 1 hour (excluding set-up time and feedback).

### **c. Training (Self-Practice)**

The goal is to improve performance (i.e., scoring relative to expert surgeons) through deliberate practice. Training duration may differ by level of experience and should be tailored to an individual's needs.

### **d. Post-Test**

Completing a monitored post-test upon completion of the training period takes approximately 45 minutes (excluding set-up time and feedback).